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TITLE: Computer architecture and process of patient generation, evolution, and simulation for computer based testing system using bayesian networks as a scripting language

Summary of Invention Paragraph (36):
[0034] The patient generation process proceeds on the basis of a specific health state identifier (coded in the database as a name and SNOMED code) passed to the process at the start of the simulation. The SNOMED International structured vocabulary is a versatile nomenclature for describing medical ideas. See, for example, Ct R A, Rothwell D J, Palotay J L, Beckett R S, Brochu L, editors, SNOMED International: The systematized nomenclature of human and veterinary medicine, 3rd ed. Northfield, Ill., College of American Pathologists, 1993, incorporated herein. by reference. This nomenclature allows one to make inferences from the codes used to represent each idea. For instance, the code F-37022 represents "retrosternal chest pain." The first character, "F," indicates that the code is from a broad class of ideas called functions. The next to digits, "37," indicate that the code involves a refinement of the code F-37000, "chest pain, not otherwise specified." Similarly, code F-37020 specifies "precordial chest pain." The code F-37022 implies that retrosternal chest pain is a kind of precordial chest pain, which is a kind of chest pain, which is a kind of function.

Summary of Invention Paragraph (41):
[0039] Logical and procedural knowledge in the database described as "reasoning elements" (RE) (for example, Bayesian network describing a generation method, Bayesian network describing a treatment plan, and the like), included in the generation methods described above, "shape selectors" which describe distributions for the n patterns by which health states evolve (patterns in turn are specified by findings and subpatterns), and courses of action (COA) which represent possible further diagnostic and management strategies which candidates might select.

Summary of Invention Paragraph (58):
[0056] Each HEALTH STATE affects multiple FINDINGS, which in turn have Specific Findings appropriate for that FINDING in that HEALTH STATE. Data such as incidence, prevalence, and attack rates are represented as PATTERNS (graphical functions which support the patient generation simulation processes). The information is collected in paper template form, and then transferred into computer-readable format using, for example, any standard Knowledge Acquisition (KA) tool to enter the information into an object-oriented database.

Summary of Invention Paragraph (75):
[0073] To achieve the above features and advantages, as well as other features and advantages that will be apparent from the detailed description provided below, a computer implemented simulation and evaluation method simulates interventions to a patient by a user, and evaluates the interventions responsive to predetermined criteria and the interventions. The method includes defining a test area to evaluate the user on at least one predetermined criterion, selecting genetic information of the patient responsive to the test area, and generating a patient history responsive to the test area and the genetic information. The method also includes receiving at least one intervention input by the user, and evaluating the user responsive to the intervention and predetermined criteria.

Summary of Invention Paragraph (78):
[0076] It is another feature and advantage of another embodiment of the instant invention to include a method for evaluating or educating a user. The method includes the following sequential, non-sequential, or sequence-independent steps. Plurality of

parallel health state networks are generated, for example, by a user or a computer. One or more first Bayesian networks, which describe each of the parallel health state networks generated by a user or a computer. One or more second Bayesian networks, which describe rates of progression within and/or between the parallel health state networks, and describe task factors that affect the rates of progression, generated by a user or a computer. One or more third Bayesian networks which support reveal structures to limit display of patient test data to patient test data specifically requested by the user, are generated by a user or a computer. One or more fourth Bayesian networks which support plan critiques of queries of and treatment prescribed by the user, are generated by a user or a computer.

Summary of Invention Paragraph (83):
[0081] Optionally, the instructions further include one or more second belief networks, which describe rates of progression within and/or between the parallel health state networks, and describe task factors that affect the rates of progression, are accessed by the computer or the user. Optionally, one or more third belief network, which supports reveal structures to limit display of patient test data to patient test data specifically requested by the user, are accessed, for example, by the computer. Optionally, one or more fourth belief networks which support plan critiques of queries of and treatment prescribed by the user, are accessed by the user or the computer. Optionally, the scripting step includes scripting the knowledge base by the computer, at least in part, from the one or more second belief networks. Optionally, a course of action or a query for a specific medical finding concerning the model patient is received by the computer from the user responsive to the instantiated model patient. If the query is received, the specific medical finding is displayed by the processor to the user based at least in part on the at least one third network, and the receiving step is repeated by the processor.

Summary of Invention Paragraph (89):
[0087] Optionally, the system includes means for generating the at least one first belief network which describes each of the plurality of parallel health state networks. Optionally, the system includes means for generating the at least one second belief network which describes rates of progression within and/or between the parallel health state networks, and describes task factors that affect the rates of progression. Optionally, the system includes means for generating the at least one third belief network which support reveal structures to limit display of patient test data to patient test data specifically requested by the user. Optionally, the system includes means for generating the at least one fourth belief network which supports plan critiques of queries of and treatment prescribed by the user.

Summary of Invention Paragraph (92):
[0090] One or more first belief networks, which describe each of the plurality of parallel health state networks, are accessed by the processor. One or more second belief networks, which describe rates of progression within and/or between the parallel health state networks, and describe task factors that affect the rates of progression, are accessed by the processor. One or more third belief networks, which support reveal structures to limit display of patient test data to patient test data specifically requested by the user, are accessed by the processor. One or more fourth belief networks, which support plan critiques of queries of and treatment prescribed by the user, are accessed by the processor. Patient data for an actual patient is received by the processor by user input.

Summary of Invention Paragraph (102):
[0100] One or more first belief networks which describe each of the plurality of parallel health state networks are accessed. One or more second belief networks, which describe rates of progression within and/or between said plurality of parallel health state networks, and describe task factors that affect the rates of progression, are accessed. One or more third belief networks, which support reveal structures to limit display of patient test data to patient test data specifically requested by the user, are accessed. One or more fourth belief networks, which supports plan critiques of queries of and treatment prescribed by the user, are accessed. A knowledge base is scripted by the processor or a user from the one or more first belief networks and the one or more second belief networks.

Summary of Invention Paragraph (108):
[0106] One or more first belief networks, which describe each of the parallel health state network, are accessed by the user or the processor. One or more second belief networks, which describe rates of progression within and/or between said plurality of parallel health state networks, and describe task factors that affect the rates of

progression, are accessed by the user or the processor. One or more third belief networks, which support reveal structures to limit display of patient test data to patient test data specifically requested by the user, are accessed by the user or the processor. One or more fourth belief networks, which supports plan critiques of queries of and treatment prescribed by the user, are accessed by the user or the processor.

Summary of Invention Paragraph (118):
[0116] One or more first belief networks, which describe each of the plurality of health states in parallel networks, are accessed by the processor or a user. One or more second belief networks, which describe transitions between health states within parallel networks, and describe task factors that affect the rates of progression, are accessed by the processor or a user. One or more third belief networks, which support reveal structures to limit display of patient test data to patient test data specifically requested by the user, are accessed by the processor or a user. One or more fourth belief networks, which support plan critiques of queries of and treatment prescribed by the user, are accessed by the processor or a user.

Summary of Invention Paragraph (121):
[0119] It is a feature and advantage of another embodiment of the instant invention to include a method for educating or evaluating a user. The method includes the following sequential, non-sequential, or sequence-independent steps. A virtual patient is instantiated for display to the user, for example, by a computer. The virtual patient includes a number of health states. A query is received from the user for a medical finding concerning the instantiated virtual patient. Optionally, responsive to the received query, a specific medical finding is generated at least in part from a first causal probabilistic network defining a health state reveal structure corresponding to the instantiated virtual patient. Optionally, responsive to the received query, an indication of an inappropriate query is generated based, at least in part, on a second causal probabilistic network defining a medical practice management plan. By way of illustration, the medical practice management plan includes healthcare provider or medical insurance-approved medical finding queries.

Brief Description of Drawings Paragraph (11):
[0135] FIG. 10 is an illustration of the entity-relationship model data structure stored in the white board database when patients are not pre-generated;

Brief Description of Drawings Paragraph (12):
[0136] FIG. 11 is an illustration of a modified entity-relationship model data structure stored in the white board database when patients are not pre-generated;

Detail Description Paragraph (18):
[0168] In general, a model describes the kinds of information that could be collected regarding a topic. For instance, a model of a mailing address should include at least a name, street address, apartment number, city, state, and ZIP code. A database built upon this model could list these items for each entry. Not every item in the model should be described for every entry in the database; many addresses have no apartment number. Incomplete database entries still provide useful information; even if a street address is missing, the city to search can be found.

Detail Description Paragraph (19):
[0169] Finally, the model limits what the database could do; it could not easily list first names. A model of diagnostic medicine of the present invention includes diseases, historical and examination data, and links between diseases and data. These models represent knowledge that physicians apply to uncertain or imprecise cases. The address example suggests a list of simple observations, called a database. A diagnostic program uses a collection of more abstract information, such as a statistical summary of a database, to draw inferences about a single case. The program and its information are often called a knowledge base.

Detail Description Paragraph (30):
[0180] We have determined that an important class of events exist in the model of family medicine, which we call "modifying relations," or modifiers. In database terms, modifiers are relations between traditional relations. Modifiers extend the conventional entity relation diagram and provide a means of managing statistically dependent events.

Detail Description Paragraph (83):
[0233] We have also determined that the structure of an interface to medical reference systems might be enhanced using the model. Current reference systems use the structure

of medical publications and lists of abstracted subject headings to facilitate searches through very large databases. These searches can yield large numbers of extraneous citations, especially for novice users.

Detail Description Paragraph (129):
[0279] Previous efforts to simulate patients from data have used sensitivity information stored in a diagnostic database, or Quick Medical Reference.RTM., to stochastically create a description of findings in a patient with a disease. See, for example, Bergeron B. Iliad: A Diagnostic Consultant and Patient Simulator, MD Computing 1991, Vol. 8, pages 46-53; Miller R A, Masarie F E, Myers J D, "Quick Medical Reference(QMR)" for diagnostic assurance, MD Computing 1986, Vol. 5, pages 34-49, incorporated herein by reference. However, we have determined that these simulations lack rich historical details and may generate implausible combinations of events. See, for example, Sumner W., A review of Iliad and QMR for primary care providers, Archives of Family Medicine 1993, Vol. 2, pages 87-95, incorporated herein by reference.

Detail Description Paragraph (226):
[0372] In accordance with one design of the present invention, when the computer based examination system generates and evolves a random patient, it cannot reuse the patient information if the patient is evolved once. That is, every time the examination is executed, we need to generate a patient to continue the test. Not only does the process of generating a patient take tremendous time, but also the evolved patient cannot generally be tested again in the future.

Detail Description Paragraph (227):
[0373] In accordance with another design of the invention, the patient is pre-generated, evolved and stored in the Whiteboard database. The presentation system can test the patient in countless time if wanted. Furthermore, different physicians can test the same patient at the same time.

Detail Description Paragraph (228):
[0374] FIG. 10 is an illustration of the entity-relationship model when patients are not pre-generated, and FIG. 11 presents the modified entity-relation diagram of the modified Whiteboard database when the patient is pre-generated. Each node represents a status of a patient with parallel health states. For example, when a patient is generated, he or she is located at node 1, the patient might be evolved to several status located at node 2, 3, 4 . . . , etc. Therefore, a patient can have many nodes.

Detail Description Paragraph (258):
[0404] The process of the computer based examination or assessment system is described in detail in connection with FIGS. 13-14. The computer implemented process includes the overall concept that the physician is presented with an examination, and the process generates multiple instances of patients. These generated patients represent clinical scenarios that a physician would have to go through to administer proper treatment. These scenarios are stored in a white board database which stores both the database implementation (i.e. the patients stored in data structures), as well as computer codes which operate from base structures including information on physician.

Detail Description Paragraph (261):
[0407] The physician/examinee is either presented with an optional list(s) of subject areas for examination or mandatory subject areas for examination in Step P4, responsive to information stored in the whiteboard database via requests thereto in Step P12. Alternatively, the examination areas might be hidden, and the examinee might be told that this is a diabetic problem, with certain management issues. The examinee may optionally have a series of selections, whether it is in terms of individual patients or they could be in specific areas.

Detail Description Paragraph (264):
[0410] Depending on the above information, the patient generator process is then initiated to create a patient for the examination in Step P16. The patient generation process may be performed in Step P18 in real-time for each patient, or may be pre-generated as described above. Under the real-time scenario, the selection of a problem area in Step P14 translates into a target health state or area.

Detail Description Paragraph (277):
[0423] The white board accesses the patient template in Step P42, and generates the patient record in Step P46, responsive to requests initiated by the white board to the patient history information in Step P44. The patient record is not generally reviewable by the examinee, except on individual requests by the examinee in Step P48. The

examinee requests information from the patient record in Step 48 which provides the examinee the physical view of the patient. For example, the patient's blood pressure may be stored in the patient record for retrieval by the examinee. Other examples of information stored in the patient record include chief complaint, past medical history, past patient behavior or compliance information.

Detail Description Paragraph (293):
[0439] The computer implemented process also includes the possibility of treating patients with management health issues that do not generally become totally normal (e.g., long term diabetes, arthritis, and the like), as well as health conditions that may return to completely normal (e.g., broken bone, and the like).

Detail Description Paragraph (299):
[0445] The patient evolution information may optionally be pre-generated for computational efficiency. That is, even when patients are created dynamically, some predetermined evolution information may be ready for use by the computer based examination system based on the potential of the possible evolution periods/health states. For example, if the target health state was moderate, the computer based examination system may have predetermined onset time of moderate, and therefore, know the time for mild, normal, severe, and the like. In effect, the white board database/object optionally includes a complete possible look at the future appearance, as well as the past characteristics for this particular patient at a particular health state.

Detail Description Paragraph (346):
[0491] The use of Bayesian networks as a scripting language has been partially tested by implementation of an object oriented database which was populated with data about OA and obesity. Expressiveness was tested in the other domains. We were actively programming an ESP that will rely almost entirely on Bayes nets and Sets of Conditions to describe conditional and probabilistic information in family medicine, and preparing to enter hypothyroidism data in an object oriented database.

Detail Description Paragraph (381):
[0524] The revised ESP model was tested by additional knowledge acquisition experiments, implementation of a Poet.TM. object oriented database and supporting algorithms, and generation of simulated osteoarthritis cases. The database was used to generate cases of osteoarthritis of the knee with obesity as a risk factor, and gastric ulcers induced by non-steroidal anti-inflammatory drugs prescribed without misoprostel.

Detail Description Paragraph (388):
[0530] The osteoarthritis experiment continued with development of an object oriented database structured after the ESP model. The database was populated with information about four stages of osteoarthritis, three weight conditions, and 2 ulcer states.

Detail Description Paragraph (455):
[0595] We will attempt to include a family physician ABFP Board of Directors member on each team to provide Board input into health state emphases. In developing diabetes mellitus and osteoarthritis, we frequently find ourselves saying, "That's an issue for ABFP to decide." For example, in assessing a candidate's ability to manage osteoarthritis of the hand, do we want to investigate the candidate's ability to interpret a hand radiograph, or rather do we want to know how the candidate uses the information that a patient's x-ray demonstrates stigmata of osteoarthritis? The first question deals with a psychomotor skill (radiograph interpretation), while the second question assesses the candidate's cognitive knowledge regarding therapy for osteoarthritis. Having an ABFP Board member on each committee should help provide ABFP input into such decisions. Nevertheless, committee member input may be highly valuable to the Board, and we encourage members to contemplate these issues: What are the critical commissions and omissions in care plans for these patients? What are the simplest approaches to improving length and quality of life? What are the common mistakes in clinical care? What are the new insights into appropriate clinical care? What are likely to be the testable concepts related to this health state domain?

Detail Description Paragraph (465):
[0605] The internet architecture 220 and ADSL architecture 254, 256 may also be combined with, for example, user networds 222, 224, and 228. As illustrated in this embodiment, users may access or use or participate in the administration, management computer assisted program in computer 240 via various different access methods. In this embodiment, the various databases 230, 232, 234, 236 and/or 238 are accessible via

access to and/or by computer system 240, and or via internet/local area network 220. These databases may optionally include objective criteria for evaluating the corporate governance characteristics for ranking the corporation.

Detail Description Paragraph (466):
[0606] For example, environmental data is generally publicly available which indicates a corporation's compliance history, outstanding violations or potential violations, and the like. Similarly, standard legal and/or regulatory and/or administrative and/or business databases may be consulted to obtain additional information on corporate governance techniques, potential for government intervention, shareholder participation and/or customer loyalty. All this data may then be collected and analyzed to determine the overall attributes of the corporate, shareholder, government, and customer agents, for input into the simulation. Alternatively, the individual data may be used and input into the simulation, and the simulation may digest or process the data individually or collectively as part of the simulation.

CLAIMS:

1. A method for evaluating or educating a user comprising the steps of: (a) generating a plurality of parallel health state networks; (b) generating at least one first Bayesian network which describes each of the plurality of parallel health state networks; (c) generating at least one second Bayesian network which describes rates of progression within and/or between said plurality of parallel health state networks, and describes task factors that affect the rates of progression; (d) generating at least one third Bayesian network which supports reveal structures to limit display of patient test data to patient test data specifically requested by the user; (e) generating at least one fourth Bayesian network which supports plan critiques of queries of and treatment prescribed by the user; (f) scripting a knowledge base from the at least one first Bayesian network and the at least one second Bayesian network; (g) instantiating a model patient, at least in part, from the scripted knowledge base; (h) receiving one of a course of action and a query for a specific medical finding concerning the model patient from the user responsive to the instantiated model patient; (i) displaying, if the query is received, the specific medical finding to the user based at least in part on the at least one third Bayesian network, and repeating step (h); (j) evolving the model patient in accordance with the plurality of parallel health state networks and responsive to the received course of action; (k) repeating the steps (h) through (j) until the user has completed treatment of the model patient; (l) generating an optimum combination of treatment and queries based, at least in part, on the at least one fourth Bayesian network and the instantiated model patient; and (m) evaluating the query and the treatment by the user in comparison to the generated optimum combination of treatment and queries.

6. The computer readable medium according to claim 5, wherein the instructions further comprise: (e) accessing at least one third belief network, which supports reveal structures to limit display of patient test data to patient test data specifically requested by the user.

22. An expert system comprising: a processor; a computer-readable medium storing instructions executable by said processor, said instructions including: (a) accessing a plurality of parallel health state networks describing at least one of a plurality of primary networks defining disease evolutions, a plurality of secondary networks defining risk factors affecting progression through a primary network of the plurality of primary networks, and a plurality of tertiary networks defining at least one of causal probabilistic medical complications attributed to at least one stage in the primary network and medical complications attributed to management of the at least one stage; (b) accessing at least one first belief network which describes each of the plurality of parallel health state networks; (c) accessing at least one second belief network which describes rates of progression within and/or between said plurality of parallel health state networks, and describes task factors that affect the rates of progression; (d) accessing at least one third belief network which supports reveal structures to limit display of patient test data to patient test data specifically requested by the user; (e) accessing at least one fourth belief network which supports plan critiques of queries of and treatment prescribed by the user; (f) receiving patient data for an actual patient by user input; (g) instantiating a virtual patient having characteristics consistent with the received patient data and based, at least in part, on the at least one first belief network and the at least one second belief network; (h) generating one of a query for a specific medical finding concerning the actual patient, and a course of action responsive to at least one health state of a plurality of health states of the virtual patient corresponding to at least part of the

received patient data; (i) receiving the specific medical finding from the user, if a query therefor is generated; and (j) evolving the virtual patient in accordance with at least one of the at least one first belief network and the at least one second belief network, and responsive to at least one of the received specific medical finding and the generated course of action.

31. A system communicatable with a computer network, comprising: a server communicatable with a user via the computer network, said server being in communication with a processor and a computer-readable medium storing instructions executable by said processor, said instructions including: (a) accessing a plurality of parallel health state networks describing at least one of a plurality of primary networks defining disease evolutions, a plurality of secondary networks defining risk factors affecting progression through a primary network of the plurality of primary networks, and a plurality of tertiary networks defining at least one of causal probabilistic medical complications attributed to at least one stage in the primary network and medical complications attributed to management of the at least one stage; (b) accessing at least one first belief network which describes each of the plurality of parallel health state networks; (c) accessing at least one second belief network which describes rates of progression within and/or between said plurality of parallel health state networks, and to describe task factors that affect the rates of progression; (d) accessing at least one third belief network which support reveal structures to limit display of patient test data to patient test data specifically requested by the user; (e) accessing at least one fourth belief network which supports plan critiques of queries of and treatment prescribed by the user; (f) scripting a knowledge base from the at least one first belief network and the at least one second belief network; (g) instantiating a model patient based, at least in part, from the scripted knowledge base; (h) receiving one of a course of action and a query for a specific medical finding concerning the model patient from the user responsive to the instantiated model patient; (i) displaying, if the query is received, the specific medical finding to the user based at least in part on the at least one third belief network, and repeating the instruction (h); and (j) evolving the model patient in accordance with at least one of the at least one first belief network and the at least one second belief network and responsive to the received course of action.

35. A computer network appliance comprising: a thin client programmably connected via a computer network to a single web hosting facility, the single web hosting facility including a server communicatable with a user via the computer network, said server being in communication with a processor and a computer-readable medium storing instructions executable by said processor, said instructions including: (a) accessing a plurality of parallel health state networks describing at least one of a plurality of primary networks defining disease evolutions, a plurality of secondary networks defining risk factors affecting progression through a primary network of the plurality of primary networks, and a plurality of tertiary networks defining at least one of causal probabilistic medical complications attributed to at least one stage in the primary network and medical complications attributed to management of the at least one stage; (b) accessing at least one first belief network which describes each of the plurality of parallel health state networks; (c) accessing at least one second belief network, which describes rates of progression within and/or between said plurality of parallel health state networks, and describes task factors that affect the rates of progression; (d) accessing at least one third belief network, which supports reveal structures to limit display of patient test data to patient test data specifically requested by the user; (e) accessing at least one fourth belief network which supports plan critiques of queries of and treatment prescribed by the user; (f) scripting a knowledge base from at least one of the at least one first belief network and the at least one second belief network; (g) instantiating a model patient, at least in part, from the scripted knowledge base; (h) receiving one of a course of action and a query for a specific medical finding concerning the model patient from the user responsive to the instantiated model patient; (i) displaying, if the query is received, the specific medical finding to the user based at least in part on the at least one third belief network, and repeating step (h); and (j) evolving the model patient in accordance with the plurality of parallel health state networks and responsive to the received course of action.

41. A system communicatable with a computer network, comprising: a server communicatable with a user via the computer network, said server being in communication with a processor and a computer-readable medium storing instructions executable by said processor, said instructions including: (a) accessing a plurality of parallel health state networks describing at least one of a plurality of primary networks defining disease evolutions, a plurality of secondary networks defining risk factors affecting

progression through a primary network of the plurality of primary networks, and a plurality of tertiary networks defining at least one of causal probabilistic medical complications attributed to at least one stage in the primary network and medical complications attributed to management of the at least one stage; (b) accessing at least one first belief network, which describes each of the plurality of parallel health state networks; (c) accessing at least one second belief network, which describes rates of progression within and/or between said plurality of parallel health state networks, and describes task factors that affect the rates of progression; (d) accessing at least one third belief network, which support reveal structures to limit display of patient test data to patient test data specifically requested by the user; (e) accessing at least one fourth belief network, which supports plan critiques of queries of and treatment prescribed by the user; (f) scripting a knowledge base from at least one of the at least one first belief network and the at least one second belief network; (g) instantiating a model patient based, at least in part, from the scripted knowledge base; (h) receiving one of a course of action and a query for a specific medical finding concerning the model patient from the user responsive to the instantiated model patient; (i) displaying, if the query is received, the specific medical finding to the user based at least in part on the at least one third belief network, and repeating the instruction (h); and (j) evolving the model patient in accordance with at least one of the at least one first belief network and the at least one second belief network and responsive to the received course of action.

45. The method according to claim 42, wherein the medical practice management plan includes healthcare provider approved medical finding queries.